

The Corps of Engineers Telescoping Weir for Confined Placement Sites

PURPOSE: This technical note describes the Corps of Engineers patented invention known as the telescoping weir.

BACKGROUND: The fundamental objective of the Innovative Technologies Focus Area of the Dredging Operations and Environmental Research (DOER) program is to identify and catalog innovative dredging operations, processes, or equipment and techniques developed by domestic and international dredging entities. A number of technologies developed within the U.S. Army Corps of Engineers are currently undergoing evaluation for potential demonstration under the DOER program. Among these is the telescoping weir, a Corps invention (patent pending) for water management in confined placement sites (Francine et al. 2000).

Confined disposal facilities (CDFs) are engineered structures designed to provide required storage volume for dredged materials and to meet required effluent solids standards specified in state water quality certificates. If properly designed, constructed, and operated, the CDF will retain the dredged material solids within its diked confines while allowing the carrier water to be released from the containment area with no more sediment in suspension than allowed under the state water quality certification. Because in almost all cases the CDF must be used over a period of many years, long-term storage capacity of the facility must be strictly managed and maximized. Gain in storage capacity within the CDF is dependent on removal of pore water within the fine-grained fraction of the dredged material allowing consolidation and desiccation. The dual requirements of short-term effluent control and long-term storage capacity are directly related to the ability of the operator to manage influent and effluent water within the CDF in an effective and efficient manner. The short-term effluent control requires a specific operational approach during active dredging projects; the long-term decanting of pore water requires another operational approach. Both approaches use a weir. The innovation regarding weir design is the subject of this technical note. A more complete treatment of design, construction, operation, and management of CDFs, including specifics of weir selection and design, can be found in Headquarters, U.S. Army Corps of Engineers (1987).

DISCUSSION OF THE CONVENTIONAL WEIR: Conventional weirs are engineered structures of various sizes, shapes, and lengths as dictated by the requirements of the CDF (Figures 1 and 2). The two most critical weir design parameters are ponding depth and weir length. In order to maintain acceptable effluent quality, the upper layers containing low levels of suspended solids should be ponded at depths greater than or equal to the minimum depth of the withdrawal zone, which will prevent scouring settled material. The withdrawal zone is the area through which fluid is removed for discharge over the weir as shown in Figure 3 (Figure 4-6 of Headquarters, U.S. Army Corps of Engineers, 1987). Efficient sedimentation is promoted by ponding water to a specified depth in the placement site. This ponded depth is controlled by the elevation of the weir crest. In conventional operations, weir boards are raised to obtain the required ponding depth and lowered periodically as the dredging rate decreases to control the effluent quality and to discharge water

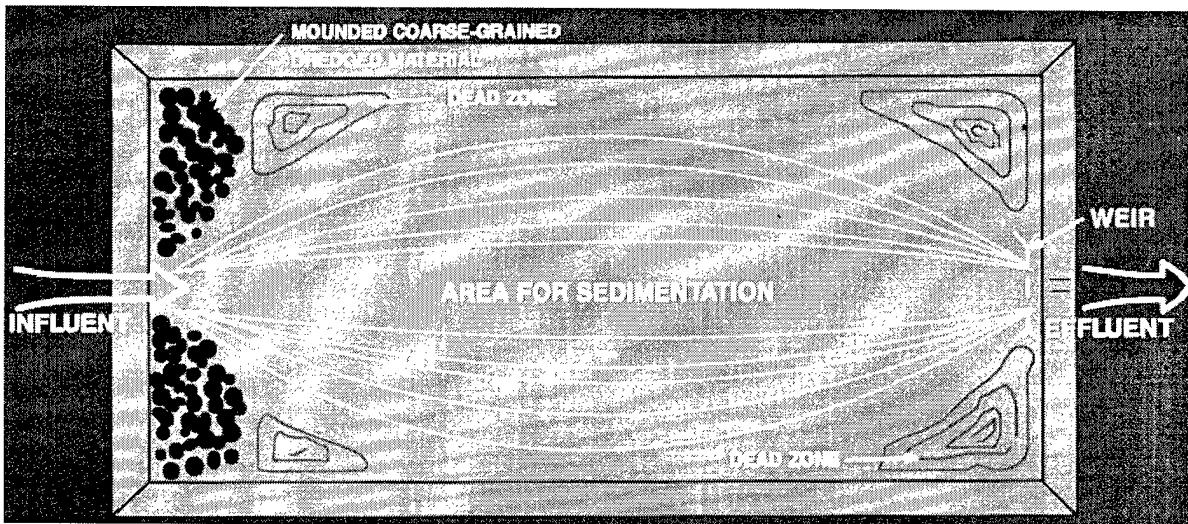


Figure 1. Schematic plan view of CDF components

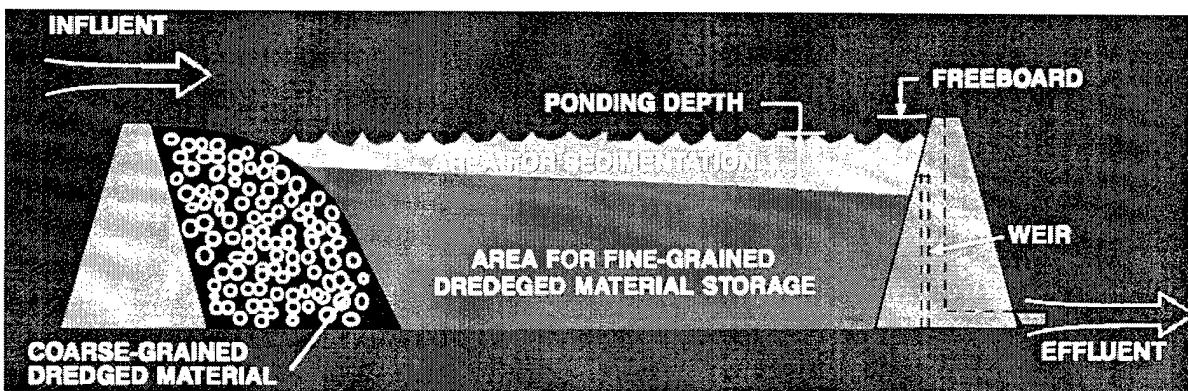


Figure 2. Schematic profile view of CDF design features

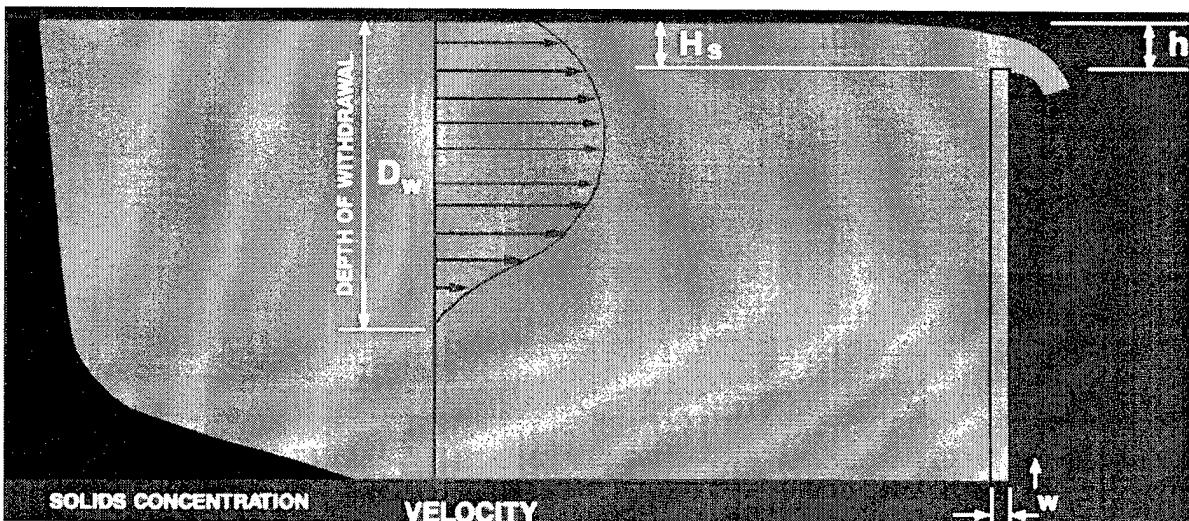


Figure 3. Conceptual illustration of withdrawal depth and velocity profiles

during dewatering operations. The tasks of raising and lowering weirs have not always been easy or safe.

Conventional weirs have numerous operational disadvantages:

- Placing or removing the weir boards at the proper time for optimum management of the effluent is difficult or impossible (Figures 4 and 5).
- The dimensions of the boards almost never match the required depth of withdrawal and the boards usually leak at the joints.
- Some weirs also present a safety hazard for someone slipping and falling into the weir during removal and placement of the weir boards (Figure 6).
- Further, it is very difficult to ensure that all weir boards are level and at the same elevation, leading to inefficiency since 100 percent of the weir crest is rarely used (Figure 7).
- Floating debris at the weir crest causes large withdrawal velocities at greater depth, thereby encouraging an additional sediment load in the effluent water.
- Conventional weirs also provide an excellent habitat for snakes, spiders, and wasps.



Figure 4. Weir boards in large weir, Blakeley Island site

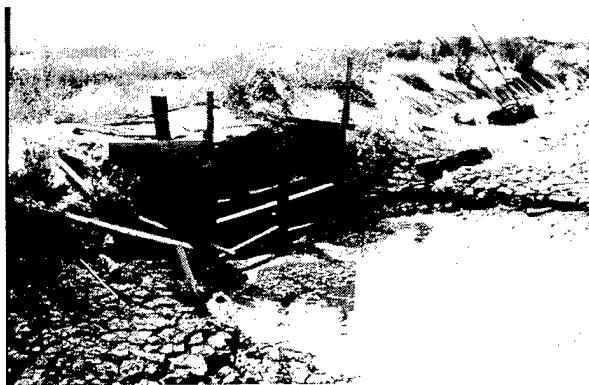


Figure 5. Nonfunctional weir boards

In summary, personnel from Corps Districts have emphasized that using conventional rectangular weir systems is tedious, manpower intensive, and expensive to maintain, has safety concerns, and, unless carefully monitored and operated, can lead to water quality problems associated with the effluent from the placement site.

DESCRIPTION OF THE TELESCOPING WEIR: The telescoping weir is an innovative structure that has the ability to closely control the environmental water quality during decantation and drainage of water from the dredged material surface of confined placement sites (Figure 8).

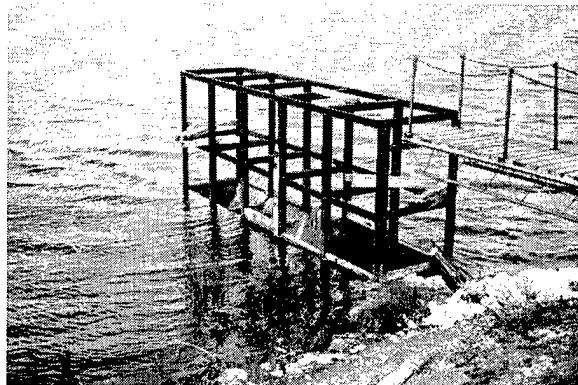


Figure 6. Example of potential safety hazard due to location of weir and boards



Figure 7. Example of unlevel weir boards and uneven effluent withdrawal across boards

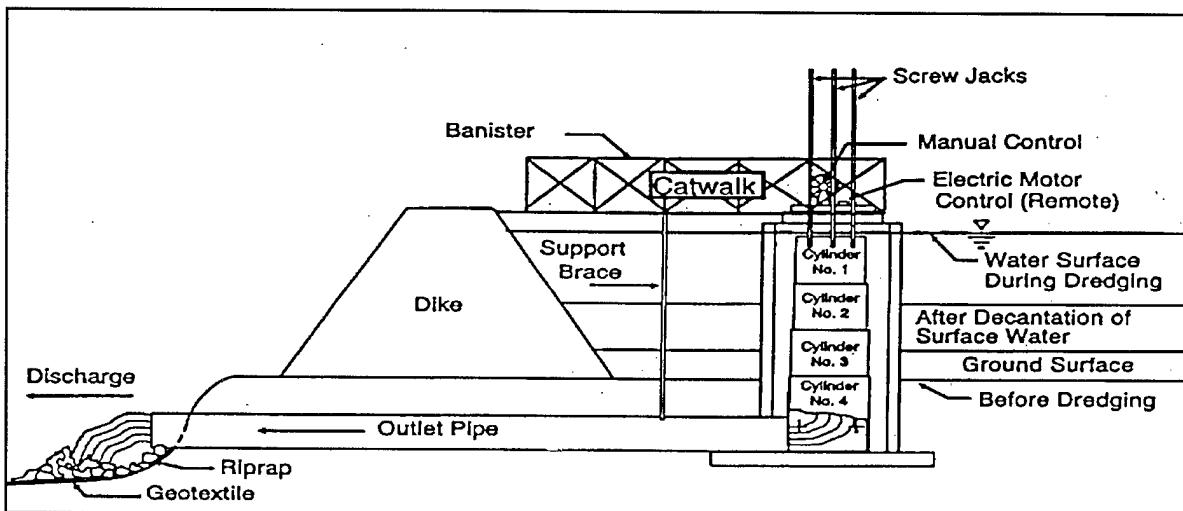


Figure 8. Schematic profile diagram, telescoping weir concept

From 1986 to 1994, the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, and the U.S. Army Engineer District, Norfolk, conceived, designed, constructed, and tested a 1/4-scale model of the first telescoping weir. The concept was originally drafted in 1986, a prototype model was constructed at WES in 1992, and the first full-size prototype telescoping weir was constructed and installed at Craney Island CDF (placement site) in 1996 (Fowler, Vann, and Woodward 1999) (Figure 9).

The major components of the telescoping weir include the following:

- Three cylindrical telescoping sections, with the upper section forming the crest of the weir.
- Seals to prevent the intrusion of sediment into the weir.
- A base section to receive the weir flow and to route it to a discharge pipe.



Figure 9. First weir installed at Craney Island CDF

charge pipe (Figure 10). The upper cylinders are extended in a telescoping manner to position the rim of the top cylinder to any desired elevation below or above the water surface (Figure 11). As the cylinders are lowered below the water surface, the decant water flows over the weir crest into the interior sections, exits through the discharge pipe in the lower section, and returns to the nearby waterway (Figure 12).

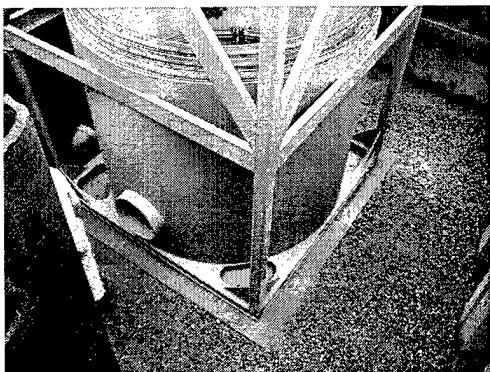


Figure 10. Anchor and foundation of telescoping weir

- A foundation to anchor the weir structure to the bottom of the placement site in which it is installed.
- A framework to support the machinery that is used to adjust the weir height.
- A set of jackscrews to raise and lower the crest of the weir.
- A motor and gear mechanism to drive the jackscrews.
- Control circuitry.
- A battery power supply.
- A solar panel to maintain the batteries in a charged state.
- A weatherproof enclosure for the controls.
- A discharge pipe adapter.
- A weir head gauge.

The weir itself consists of a set of nested cylinders set on end with their axes vertical. The bottom cylinder is fixed to a steel frame foundation that is anchored to a concrete pad at the bottom of the placement site and connected to a discharge pipe (Figure 10). The upper cylinders are extended in a telescoping manner to position the rim of the top cylinder to any desired elevation below or above the water surface (Figure 11). As the cylinders are lowered below the water surface, the decant water flows over the weir crest into the interior sections, exits through the discharge pipe in the lower section, and returns to the nearby waterway (Figure 12).

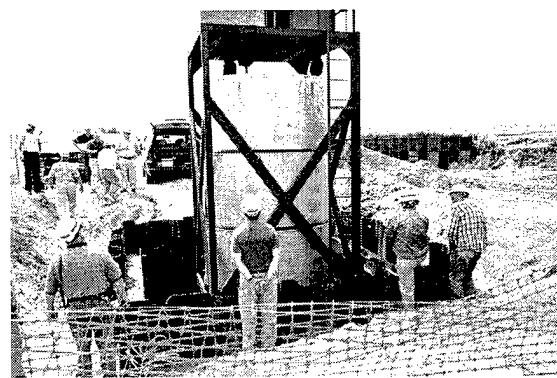


Figure 11. Extended telescoping cylinders at Blakeley

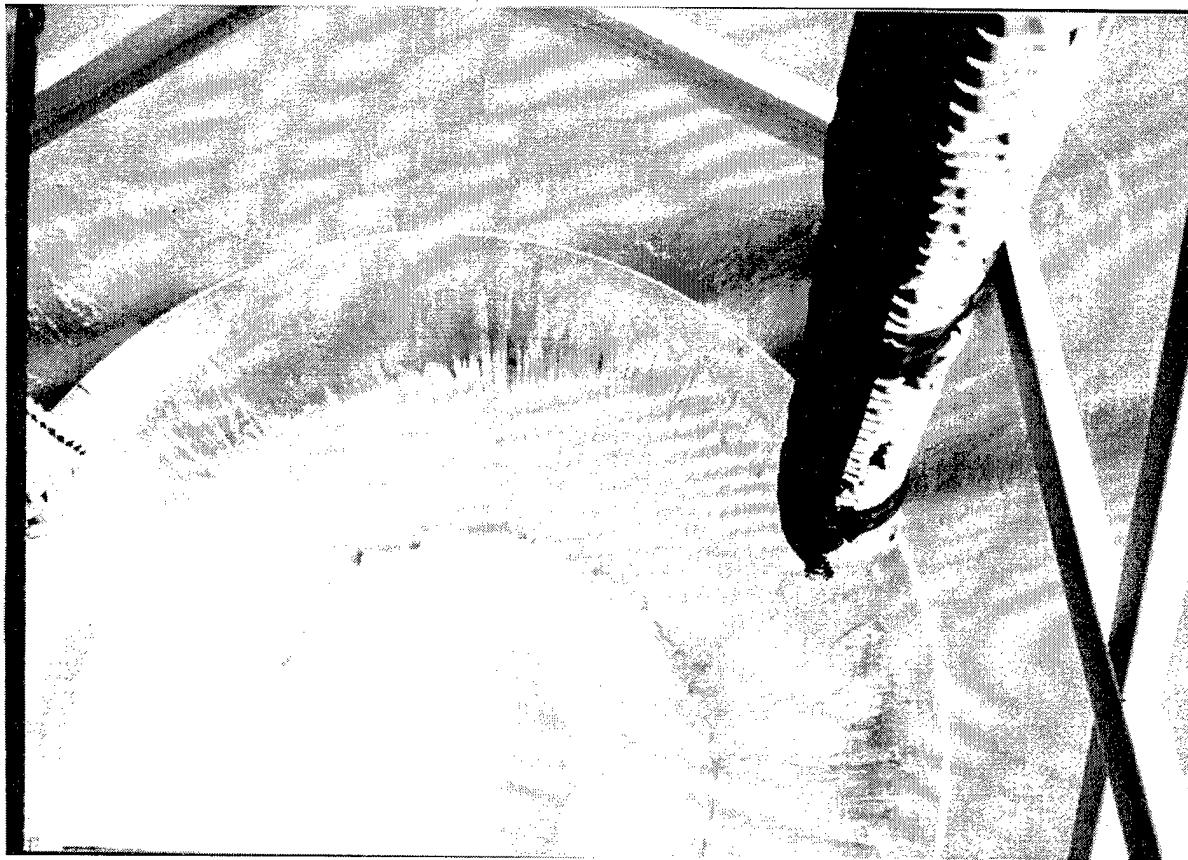


Figure 12. Clear waters flowing over telescoping weir crest

The telescoping weir is set within and attached to the base of a reaction frame that provides support for it and the machinery that controls the telescoping movements of the weir. The telescoping weir is raised and lowered via mechanical jackscrews that operate simultaneously either manually or by solar/battery-powered motor. Technical specifications for the major telescoping weir components of the weirs installed at Craney Island are described in Appendix I.

ADVANTAGES OF THE TELESCOPING WEIR: The innovative telescoping weir has numerous advantages. The principal advantage is being able to provide an infinite adjustment of the weir crest elevation (within the design height of the weir) and discharge velocities at the touch of a button. The crest of the telescoping weir can be lowered easily to the bottom of the desiccation cracks in the dredged material. This flexibility also provides efficient control of surface runoff, enhancement of the desiccation and the drying processes, and some measure of mosquito control. The telescoping weir reduces labor requirements and costs through the elimination of weir board handling, weir board replacement, weir maintenance, and possible weir failure. The telescoping weir promotes safer field operations, which is another significant advantage. It can be equipped with a variety of sensors to measure effluent turbidity, temperature, pH, and oxygen levels. Most significantly, this innovative technology provides a new standard for weirs used in confined placement areas for dredged material that has been very difficult to improve upon for many years.

CONSIDERATIONS IN SELECTING TELESCOPING WEIRS: Engineer Manual 1110-2-5027 (Headquarters, U.S. Army Corps of Engineers, 1987) provides guidance in design, construction, operation, and management of CDFs to achieve dredging project goals. A set of the logical steps in the CDF design procedure is presented to assure adequate settling performance and initial storage volume.

Presently, selection and design of a telescoping weir are not as clearly understood as those for conventional weirs due to the limited operating information upon which to base an empirical design. For example, there may be limitations in the fabrication process that will not allow for increases in the diameter of the stainless steel cylinders. Considerations in shipping overland by truck may limit the overall width dimensions. At some point there is a practical limitation that would lead one to select multiple weirs to handle larger flows. For these and other technical and practical reasons, there is only one telescoping weir size to choose from at this time. (The topic of design of the telescoping weir will be covered in a future DOER technical note.)

However, this section lists the principal factors deemed critical to properly selecting and installing a telescoping weir for use in an existing or new site. If the following factors cannot be achieved, then the telescoping weir may not be the best choice for a water control structure in the confined placement site:

- Acceptable site for weir placement.
- Acceptable route for weir discharge pipeline.
- Acceptable energy gradient for discharge pipeline.
- Sufficient freeboard within CDF for efficient operation.
- Acceptable bearing capacity for the weir, its superstructure, and foundation pad.
- Access road to the site of the weir location.
- Access to site for installation of cofferdam (if needed during construction phase).
- Access to site for installation of piling (if necessary for increased bearing capacity).

The following are lessons learned that must be taken into consideration when selecting a telescoping weir:

- Safety is the primary consideration under site suitability.
- CDF shape and size are factors in determining the best location and size of a telescoping weir.
- Projected life of the CDF project needs to be considered as a factor in determining site suitability.
- Project sponsor issues must be considered in the planning stage.
- 401 water quality certification requirements must be considered in all phases of implementation.
- Operability (ease of operation) is an essential quality of a telescoping weir.
- Economics must be considered in a preliminary fashion during the planning stages but can be addressed in detail after design is completed in the engineering phase.

- Protection of the weir from floating debris is a requirement.
- Design for cold weather (ice) conditions may be required in some regions.
- The discharge pipeline must have a cutoff system in the event of weir malfunction.

COSTS: The following are major elements and preliminary costs for acquiring a telescoping weir based on the recent installation at Blakeley Island CDF in the U.S. Army Engineer District, Mobile.

Major Element	Preliminary Cost
Site Preparations (Site Selection, Site Survey/Processing, etc.)	\$3,000
Boring/Geotech Data Collection & Evaluation	\$5,000
Foundation Platform Construction/Preparation	\$25,000
Weir Fabrication, Delivery & Installation (estimated)	\$125,000
Weir Drain Pipe Procurement/Installation (estimated)	\$100,000
Total	\$258,000

EXPERIENCES AT CRANEY ISLAND: To date, three full-size telescoping weirs have been installed at the Craney Island placement site in Norfolk, VA. The first prototype telescoping weir was installed in April 1996, the second was installed in June 1998, and the third was installed in April of 1999. The first weir performed very effectively, which led to the installation of the two additional weirs. In 1999, the Norfolk District was able to accommodate a record annual placement of six million cubic yards of maintenance dredged material, which was not possible prior to the installation of the telescoping weir. The ability to continually meet water quality discharge standards with the telescoping weir eliminated the usual temporary shutdowns of two very large dredging projects.

The first two weirs are operational and have required little maintenance to date. However, some problems were experienced during dredging operations in July 2000 with the first weir installed at Craney Island. A telescoping section of the weir separated while being operated by the dredging contractor personnel. When this occurred, the operator began lowering the weir, resulting in damage (bending) to the three jackscrews. The Norfolk District and its contractor are presently determining if there was a design flaw in the prototype unit or material failure and operator error or both. A bearing block and/or the associated connecting rim are suspected to have failed causing the separation of the top section of the telescoping weir unit. These connections were recognized as significant stress points and all weirs, after the initial prototype, have improved bearing blocks and connecting rims, along with improved seals.

CONCLUSIONS AND RECOMMENDATIONS

- Four telescoping weirs have been successfully designed, fabricated, and installed in the Craney Island and Blakeley Island confined disposal sites.
- Two of the weirs have been demonstrated to meet both water quality and solids storage requirements at Craney Island.
- The telescoping weir has been successfully transferred from the Norfolk District to the Mobile District.

- The failure of the telescoping weir by pulling apart should be fully investigated, and corrections should be made to either the design/fabrication or operating procedures or both.
- The design basis for the telescoping weir needs to be better understood and documented for future projects.
- The possible ranges of design conditions (e.g., flow, salinity, suspended solids, etc.) should be evaluated to provide the empirical basis for future designs.

TECHNOLOGY TRANSFER: The Innovative Technologies Focus Area under the DOER program has been assisting the Norfolk District to transfer the technology to various Corps users, including the Mobile District. The first inter-district technology transfer installation was in the Upper Blakeley Island CDF in the upper Mobile Harbor, Alabama. Delivery and installation of the system were completed on July 19, 2000. This partnership between the Mobile and Norfolk Districts and the DOER program serves to promote the use of the telescoping weir and will aid in this technology transfer to other Corps Districts.

The innovative device has high potential to be used throughout the Corps and industrial facilities worldwide. Patents for the telescoping weir are being processed with the U.S. Patent and Trademark Office and with foreign countries.

In addition to the technical assistance being provided under DOER, the U.S. Army Engineer Research and Development Center has signed an agreement with the Norfolk District to license the telescoping weir to commercial entities. Negotiations are presently ongoing with two companies to license the technology for commercial sale. The telescoping weir should be fully licensed and available to the public in 2001.

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Francingues, N. R., McNair, E. C., Vann, R. G., and Woodward, T. D. (2001). "The Corps of Engineers telescoping weir for confined placement sites," *DOER Technical Notes Collection* (ERDC TN-DOER-T3), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/dots/doer

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Fowler, J., Vann, R. G., and Woodward, T. D. (1999). "Development and application of the telescoping weir for dredged material containment facilities," *Journal of Dredging Engineering*, Western Dredging Association, 1(3), 1-14.

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Headquarters, U.S. Army Corps of Engineers. (1987). "Confined disposal of dredged material," Engineer Manual 1110-2-5027, Washington, DC.

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APPENDIX I

TELESCOPING WEIR TECHNICAL SPECIFICATIONS USED FOR PROCUREMENT AND INSTALLATION AT CRANEY ISLAND

The following specifications are based on structural and mechanical design of the specific size weirs installed in Craney Island. The unit design was designed to meet a range of water and dredged material storage levels common to most placement sites. The design life of a 12-ft telescoping weir was estimated to be 10-15 years depending on the rate of filling and material consolidation within the placement site.

Weir Crest Vertical Movement. The weir crest shall be movable over a range of 138 in. \pm 2 in. between its extreme low and high positions, as determined by mechanical stops. Electrical switches that shall be set to halt movement approximately 1 in. short of the mechanical stops shall limit the travel. There shall be sufficient length of vertical actuator to assure that, in the event of failure of the limit switches, the weir reaches its mechanical stops before the actuators reach the end of their stroke.

Adjustment Rate. When driven by the electrical motor, the weir height shall be adjustable at a rate of not less than 2 in. per minute.

Flow Rate. The weir shall be capable of a maximum flow rate of approximately 25 cfs with a head of 6 in. on the weir crest. It is infinitely adjustable to be capable of being set at the maximum flow rate consistent with avoiding turbidity in its discharge under any given operating conditions.

Power Requirements. Weir height adjustment is expected to require an input of approximately 0.25 horsepower to lift the dead weight of the weir sections at the adjustment rate of 2 in. per minute. A motor rated at 1/3 horsepower will be required for reserve power to overcome adverse environmental conditions.

Measurement of Flow Head. The head of the water above the crest of the weir shall be indicated by a mechanical gauge that can be read in ordinary daylight at a distance of 100 ft, and can also be read by a person standing on the platform of the weir.

Control Means. The weir adjustment mechanism shall be capable of being actuated in three different modes. It can be adjusted either by manipulation of a handwheel or by operation of an electric motor. The motor can be switched either at the control box located at the weir or from a distance by means of a hand-held control.

Weight and Envelope Dimensions. The weight of the weir as installed shall be no more than 15,000 lb. The envelope of the weir as installed shall be 8 ft wide by 8 ft long by approximately 28 ft tall measured from the bottom of the foundation to the top of the weatherproof covers that protect the jackscrews.

Weir Crest Section. The weir crest section shall be a thin-walled cylinder of corrosion-resistant steel, nominally 85.5 in. in outside diameter, 48 in. long, and 0.25 in. thick. A set of bearing blocks shall be attached around the lower perimeter of the crest section to engage the upper rim of the

second section and lift it when the weir is being extended. The blocks shall also act as mechanical stops for the weir section as it is lowered to nest in the next lower section.

Telescoping Sections. There shall be two cylindrical telescoping sections below the crest section. Each shall be large enough in diameter to permit the next upper section to slide within it, with allowance made for the slide bearings described later. Each shall be of corrosion-resistant steel of thickness adequate to withstand the hydrostatic pressure of a soil overburden resulting when the sediment at the installation site has built up to the full extended height of the weir. Each shall have an upper rim that serves as a seat for the wiper seal described later. Each shall have a set of bearing blocks attached around the lower perimeter to engage the upper rim of the next lower section when the sections are being telescoped.

Base Section. The base section shall be a fixed cylindrical section, large enough in diameter to permit the next upper section to slide within it, with allowance made for the slide bearings described later. It shall be of structural steel of thickness adequate to withstand the hydrostatic pressure of a solid overburden resulting when the sediment at the installation site has built up to the full extended height of the weir. It shall have an upper rim that serves as a seat for a wipe seal described later. A flat plate seals its lower end. Near its lower end a pipe joint that will serve as the connection for the discharge pipe shall intersect the cylindrical wall. The pipe joint outside diameter shall be not less than 24 in. The height of the base section shall be large enough to allow the telescoping sections to nest within it without significantly blocking the flow through the discharge pipe.

Slide Bearings. The inner wall of each weir section, except for the crest section, shall be fitted with rectangular strips of a low-friction material that act as both spacers to maintain concentricity between adjacent sections and as slide bearings to minimize the frictional resistance to the telescoping motion of the weir. These slide bearings shall be positioned adjacent to the bearing blocks described earlier in such a way to prevent the rotation of one section with respect to another.

Seals. A flexible seal, such as a lip seal, shall be installed at the joint between each weir section to prevent the intrusion of sediment into the weir discharge effluent. The seal shall be sufficiently stiff to maintain its shape and effectiveness while the weir sections are being raised through the overlying mud strata.

Weir Foundation. The weir foundation shall be a grid formed of structural beams in a pattern suitable to support the weir base section and to provide attachment to the concrete pad supported by piling in the bottom of the placement site. The foundation shall be 96 in. square, with a circular area of diameter 94 in. in the center being reserved for the weir structure. The remaining area is available for attachment to the pilings or other preparation for installation into the bed of the placement site.

Framework. The framework shall be a tower of structural beams, attached at its lower end to the foundation and topped by a platform on which are mounted the controls and the motor and gear mechanism that raise and lower the weir. The width and height of the framework shall be sufficient to straddle the weir without obstructing flow over the weir crest.

- Bracing on one side of the framework shall be removable to allow insertion of the weir telescoping sections.

- There shall be a covered manhole in the platform to allow access to the interior of the weir when it is fully raised.
- A ladder shall extend from the lower end of the framework to the platform. The ladder shall be strong enough to support one end of an aluminum catwalk of up to 40 ft in length and a minimum weight of 800 pounds, plus an additional weight of 1,000 pounds for personnel and equipment.
- The platform shall include handrails adjacent to the top of the ladder to protect personnel standing on the platform.

Jackscrews. The jackscrews shall be a set of three Acme screw assemblies, sufficient in length to reach from the framework platform to the top of the weir crest sections when fully retracted. Each screw shall be mounted to operate as a translational actuator (no rotation of the screw). Each screw passes vertically through a worm gear drive on the drive mechanism platform; the three actuators shall be mechanically coupled so that the screws are drawn up in unison to hold the weir crest level throughout its travel. One jackscrew shall be fitted with an electrical limit switch, set to stop weir travel 1 in. short of the mechanical stops. Each screw shall be protected from sediment and debris by a bellows-type boot that prevents sediments from being carried into the actuator drive as the screw passes through. The boot may be permeable to water; however, the actuator shall be of bronze construction to protect it from corrosion. System backlash due to construction and monitoring of the jackscrews shall not result in an out-of-level condition at the weir crest in excess of 0.25 in.

Motor and Gear Mechanism. There shall be a d-c gear motor, rated at not less than 1/3 horsepower. Batteries that are recharged by a solar cell array so that they can automatically renew their charge after any adjustment of the weir shall power it. The motor speed shall be geared down to deliver a linear actuation force to the jackscrews of not less than 10,000 lbf total, and a linear velocity at the weir crest of not less than 2 in. per minute.

Controls. The controls shall be divided into three classes:

- Local controls.
- Remote controls.
- Manual controls.

The local and remote controls are essentially the same and provide manual operation of the weir height adjustment. The difference is that the remote controls allow weir adjustment by hand-held control from up to 100 ft away while the local controls are located on the weir platform.

Battery Power. Conventional 12-volt automobile storage batteries shall be used, carrying a charge sufficient to operate the weir through a full cycle of extension and retraction.

Solar Panel. A solar panel shall be provided having sufficient capacity to fully recharge the system batteries within 5 days of average weather conditions after they have been discharged by operating the weir through a full extend and retract cycle. It shall be mounted on a mast that allows it to be aimed in the direction and azimuth best suited to the latitude at the weir site.

Shelter. A weatherproof shelter to protect the control and drive mechanisms shall enclose the upper platform of the framework with the following requirements:

- The shelter shall provide room for personnel to stand while performing routine inspection and maintenance.
- It shall be accessed through a door capable of being locked.
- The door shall be located to allow adequate space on the platform outside of the door to stand while the door is being opened.
- The interior shall be lighted.
- The shelter shall be designed to prevent birds from entering and roosting.

Discharge Pipe Adapter. The adapter shall be a separate cylindrical piece having the same diameter as the discharge port of the base section. The adapter shall have a bolt flange at one end matched to the flange of the discharge port and a bolt flange at the other end matched to the flange of the discharge pipe selected by the customer.

Weir Head Gauge. A float-actuated pointer shall be mounted at the weir crest to measure the height of the water flowing over the crest with the following requirements:

- The gauge shall register over a range of 0 to 8 in.
- The gauge shall be visible and legible both from the control box on the weir platform and from any point within 100 ft in front of the weir.

Reliability. The weir and associated equipment will be designed for a minimum 10-year service life under normal operating conditions without replacement, except that seals and protective boots subject to incidental damage and abrasion may need to be replaced more frequently.

Maintainability. Routine scheduled maintenance will be required under normal operating conditions. All operating parts of the weir and its control equipment will be accessible for replacement in the event of damage.

Environmental Conditions. The weir and associated equipment will be designed for continuous exposure to sea water, fresh water, and salt spray over the course of its service life.

Construction Materials. All telescoping weir sections will be made of type 304 stainless steel or better. The base sections, foundation, and framework will be of structural steel. The shelter frame will be of steel angle; its sheathing will be nonmetallic. All non-stainless steel will be protected with a marine grade coating system, the highest corrosion resistance epoxy, or zinc-base paint.